

VOLTAGE TRACKING OF DC-DC BOOST CONVERTER USING GAUSSIAN
FUZZY LOGIC CONTROLLER

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ABSTRACT

DC-DC converters are electronic devices used to change DC electrical power efficiently from one voltage level to another. Operation of the switching devices causes the inherently nonlinear characteristic of the DC-DC converters including one known as the Boost converter. Consequently, this converter requires a controller with a high degree of dynamic response. Proportional-Integral- Differential (PID) controllers have been usually applied to the converters because of their simplicity. However, the main drawback of PID controller is unable to adapt and approach the best performance when applied to nonlinear system. It will suffer from dynamic response, produces overshoot, longer rise time and settling time which in turn will influence the output voltage regulation of the Boost converter. Therefore, the implementation of practical Fuzzy Logic controller that will deal to the issue must be investigated. Fuzzy logic controller using voltage output as feedback for significantly improving the dynamic performance of boost dc-dc converter by using MATLAB@Simulink software. The design and calculation of the components especially for the inductor has been done to ensure the converter operates in continuous conduction mode. The evaluation of the output has been carried out and compared by software simulation using MATLAB software between the open loop and closed loop circuit. The simulation results are shown that voltage output is able to be control in steady state condition for DC-DC boost converter by using this methodology. Scope of this project limited only one types that is Gaussian membership function.

ABSTRAK

Penukar DC-DC adalah litar elektronik kuasa yang menukarkan satu aras voltan DC kepada satu aras voltan DC yang lain. Penukar *Boost* digunakan untuk meningkatkan voltan masukan untuk memenuhi syarat yang dikehendaki oleh sesuatu operasi. Operasi peranti pensuisan yang tak linear memerlukan pengawal *Proportional-Integral-Differential (PID)*. Walau bagaimanapun, kelemahan utama pengawal PID tidak dapat menyesuaikan diri dan mendekati prestasi terbaik apabila merujuk kepada sistem tak linear seterusnya akan mempengaruhi peraturan voltan keluaran penukar Boost. Oleh itu, pelaksanaan pengawal Fuzzy Logik diperkenalkan bagi meningkatkan prestasi dinamik dengan menggunakan MATLAB @ Simulink perisian. Reka bentuk dan pengiraan komponen terutama bagi induktor telah dilakukan untuk memastikan penukar beroperasi dalam mod konduksi berterusan. Penilaian output telah dijalankan dan dibandingkan dengan perisian simulasi menggunakan perisian MATLAB antara litar gelung terbuka dan gelung tertutup.

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LIST OF SYMBOLS AND ABBREVIATIONS

μ_e	-	degree of membership function of error
$\mu_{\Delta e}$	-	degree of membership function of delta of error
μ_u	-	degree of membership function of voltage output
μ_o	-	output of COG
\vee	-	maximum operator
\wedge	-	minimum operator
B	-	Bisector of Area
C	-	Capacitor
CCM	-	Continuous Conduction Mode
ce	-	Change of Error
COG	-	Centroid of Gravity
D	-	Duty Cycle
DC	-	Direct Current
DCM	-	Discontinuous Conduction Mode
e	-	Error
FLC	-	Fuzzy Logic Controller
Fs	-	Frequency Switching
gaussmf	-	Gaussian Membership Function
GUI	-	Graphical User Interface
KD	-	Derivative gain
KI	-	Integral gain
KP	-	Proportional gain
L	-	Inductor
MF	-	Membership Function
MOM	-	Mean of Maximum

MOSFET	-	Metal–Oxide–Semiconductor Field-Effect Transistor
NB	-	Negative Big
NS	-	Negative Small
PB	-	Positive Big
PID	-	Proportional Integral Derivative
PS	-	Positive Small
PWM	-	Pulse Width Modulation
R	-	Resistor
S	-	Switch
V_C	-	Voltage (Calculation)
V_o	-	Output Voltage
V_s	-	Input Voltage
K_{th}	-	switching cycle
V_{ref}	-	Reference output
ZE	-	Zero



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CHAPTER 1

INTRODUCTION

1.1 Project overview

DC-DC converters are electronic devices used to change DC electrical power efficiently from one voltage level to another. The advantages over AC because DC can simply be stepped up or down. They provide smooth acceleration control, high efficiency, and fast dynamic response. DC converter can be used in regenerative braking of DC motor to return energy back into the supply, and this feature results in energy saving for transportation system with frequent stop; and also are used, in DC voltage regulation (**Rashid, 2004**). In many ways, a DC-DC converter is the DC equivalent of a transformer. There are **FOUR** main types of converter usually called the **buck, boost, buck-boost and Boost** converters. The buck converter is used for **voltage step-down/reduction**, while the boost converter is used for **voltage step-up**. The buck-boost and Cuk converters can be used for **either step-down or step-up**.

Basically, the DC-DC converter consists of the power semiconductor devices which are operated as electronic switches and classified as switched-mode DC-DC converters. Operation of the switching devices causes the inherently nonlinear characteristic of the DC-DC converters. Due to this unwanted nonlinear characteristics, the converters requires a controller with a high degree of dynamic

response. Pulse Width Modulation (PWM) is the most frequently consider method among the various switching control method (**J. Alvarez-Ramirez, Jan. 2001**) . In DC-DC voltage regulators, it is important to supply a constant output voltage, regardless of disturbances on the input voltage.

Controller for the PWM switching control is restraining to Proportional-Integral-Differential (PID) controller. This controller often applied to the converters because of their simplicity. However, implementations of this control method to the nonlinear plants such as the power converters will undergo from dynamic response of the converter output voltage regulation. In general, PID controller produces long rise time when the overshoot in output voltage decreases.

Nowadays, the control systems for many power electronic appliances have been increasing widely. Crucial with these demands, many researchers or designers have been struggling to find the most economic and reliable controller to meet these demands. The idea to have a control system in dc-dc converter is to ensure desired voltage output can be produced efficiently as compared to open loop system.

In this project, MATLAB/Simulink is used as a platform in designing the fuzzy logic controller. MATLAB/Simulink simulation model is built to study the dynamic behavior of DC-DC converter and performance of proposed controller.

1.2 Problem statement

DC-DC converter consists of power semiconductor devices which are operated as electronic switches. Operation of the switching devices causes the inherently nonlinear characteristic of the DC-DC converters including one known as the Boost converter. Consequently, this converter requires a controller with a high degree of dynamic response. Proportional-Integral- Differential (PID) controllers have been usually applied to the converters because of their simplicity. However, the main drawback of PID controller is unable to adapt and approach the best performance when applied to nonlinear system. It will suffer from dynamic response,

produces overshoot, longer rise time and settling time which in turn will influenced the output voltage regulation of the Boost converter.

In general, PID controller produces long rise time when the overshoot in output voltage decreases.(**W.M.Utomo, April 2011**). Therefore, the implementation of practical Fuzzy Logic controller that will deal to the issue must be investigated. The Fuzzy control is a practical alternative for a variety of challenging control applications because Fuzzy logic control is nonlinear and adaptive in nature that gives it a robust performance under parameter variation and load disturbances. Fuzzy controllers are more robust than PID controllers because they can cover wider range of operating conditions than PID, and can also operate with noise and disturbance of different natures. Developing the fuzzy controller is cheaper than developing a model based or other controllers for the same purpose.

Fuzzy logic is suited to low-cost implementations and systems of fuzzy can be easily upgraded by adding new rules to improve performance or add new features.

1.3 Project objective

The objectives of this project are;

- i) To model and analyse a DC-DC Boost converter without controller (open loop) and simulate using MATLAB Simulink.
- ii) To design fuzzy logic controller (FLC) to control the switching of DC-DC Boost converter.
- iii) To analyze the voltage output for DC-DC Boost converter between open loop , PID controller and fuzzy logic controller.

1.4 Project scope

The scopes of this project is to simulate the proposed method of voltage tracking of DC-DC boost converter using Gaussian fuzzy logic controller with MATLAB Simulink software. Analyses of the converter will be done for continuous current mode (CCM) only. The scope of proposed fuzzy logic controller is limited Gaussian as a proposed controller. The analysis only covered the output voltage based on reading on overshoot ratio, rise time, peak time and settling time

1.5 Project report layout

This project report is organized as follows;

- i) Chapter 1 briefs the overall background of the study. A quick glimpse of study touched in first sub-topic. The heart of study such as problem statement, project objective, project scope and project report layout is present well through this chapter.
- ii) Chapter 2 covers the literature review of previous case study based on fuzzy logic controller background and development. Besides, general information about Boost Converter and theoretical revision on fuzzy logic control system also described in this chapter.
- iii) Chapter 3 presents the methodology used to design open loop Boost Converter and fuzzy logic controller. All the components that have been used in designing of fuzzy logic controller are described well in this chapter.
- iv) Chapter 4 reports and discuss on the results obtained based on the problem statements as mentioned in the first chapter. The simulation results from

Open loop, PID controller and the proposed of fuzzy logic controller will be analyzed with helps from set of figures and tables.

- v) Chapter 5 will go through about the conclusion and recommendation for future study. References cited and supporting appendices are given at the end of this project report.



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CHAPTER 2

LITERATURE REVIEW

2.1 Existing Models

Since fuzzy logic controller can mimic human behaviour, many researchers applied fuzzy logic controller to control voltage output. A thorough literature overview was done on the usage of fuzzy logic controller as applied DC-DC Boost Converter.

Ismail, N.F.N. Musirin, I. ; Baharom, R. ; Johari, D (2010) proposed a fuzzy logic controller using voltage output as feedback for significantly improving the dynamic performance of boost dc-dc converter by using MATLAB@Simulink software. The simulation results are shown that voltage output with fuzzy logic controller with 0% overshoot shows the better performance compared to the open loop circuit (without fuzzy logic controller) whereby it has 80% overshoot.

Nik Ismail, N.F. Hashim, N. ; Baharom, R. (2011) proposed comparative performance between Fuzzy Logic controller (FLC) and Proportional Integral Derivative controller (PIDC) on DC/DC Buck-Boost Converter using Matlab/Simulink. Fuzzy Logic Controller gives very good dynamic respond compare to PIDC controller.

Md. Shamim-Ul-Alam, Muhammad Quamruzzaman and K. M. Rahman (2010) proposed design of a sliding mode controller based on fuzzy logic for a dc-dc

boost converter. Sliding mode controller ensures robustness against all variations and fuzzy logic helps to reduce chattering phenomenon introduced by sliding controller, thereby increasing efficiency and reducing error, voltage and current ripples. The proposed system is simulated using MATLAB/SIMULINK. This model is tested against variation of input and reference voltages and found to perform better than conventional sliding mode controller.

Ahmed Rubaai, Mohamed F. Chouikha (2004) proposed controllers for DC-DC converters. Simulation results have been obtained using appropriate scaling factors associated with the input variables of the fuzzy controller. Simulation results show the ease of applying fuzzy control to dc/dc converters, as an interesting alternative to conventional techniques.

Based on those related work, the researchers make a great efforts to propose the good to overcome the DC-DC Converter problems. Their applications of each method differ, thus the further investigation of this controller is needed.

2.2 DC to DC Converter

DC to DC is an electronic circuit which converts a source of direct current (DC) from one voltage level to another. In other word, converting the unregulated DC input to controlled DC output with a desired voltage level. Dc to dc converter are widely used in switched-mode power supplies (SMPS), battery chargers, adjustable speed drives, uninterruptible power supplies and many other applications to change the level of an input voltage to fulfil required operating conditions. There are typically three types of dc to dc converters, which are :-

- i. Buck converter
- ii. Boost converter
- iii. Buck-Boost converter

2.3 Boost Converter

A boost converter (step-up converter), steps up the input DC voltage value and provides at output. It consists of an inductor L , capacitor C , controllable semiconductor switch S , diode D , and Load resistance R as depicted by Figure 2-1. Capacitors are generally added to output so as to perform the function of removing output voltage ripple. The boost converter is one of the most important nonisolated step-up converters.

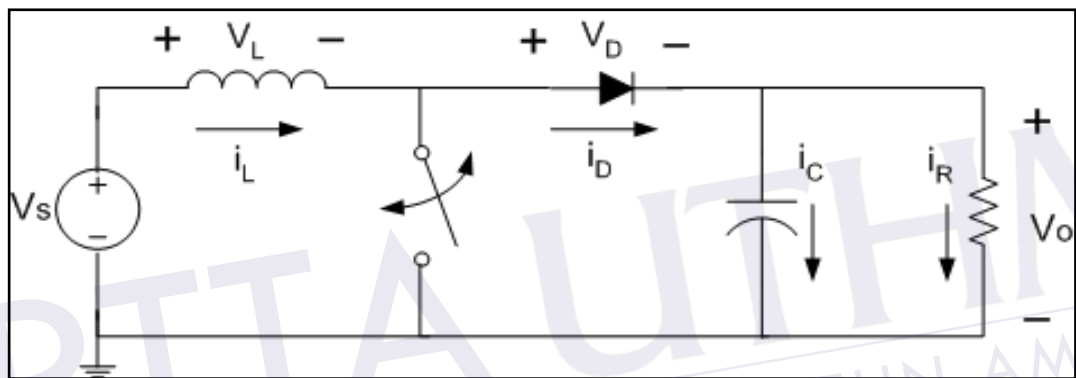


Figure 2-1 A Boost Converter Circuit

Boost converter operates, assume that the inductor is charged in the previous cycle of operation and the converter is at the steady state operation and CCM Condition.

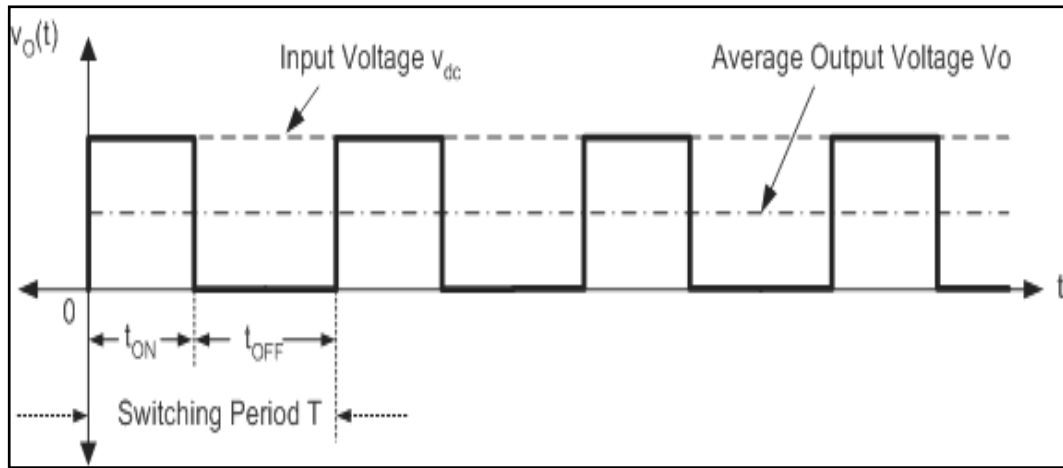


Figure 2- 2 The Duty Cycle For Switching Period During Steady State

Define Duty Cycle (D) which depends on t_{on} and switching frequency f_s

$$D = \frac{t_{on}}{t_{on} + t_{off}} = \frac{t_{on}}{T} = t_{on} f_s \quad (2.1)$$

During steady state operation the ratio between the output and input voltage is $\frac{1}{1-D}$, the output voltage is controlled by varying the duty cycle. Range of Duty Cycle: $0 < D < 1$.

$$t_{on} = DT \quad (2.2)$$

$$t_{off} = (1 - D)T \quad (2.3)$$

2.3.1 Analysis for switch closed (On)

Start with the power switch S is closed. Now the diode will be reversed-biased by the capacitor voltage, hence it will act as open. The equivalent circuit is shown in Figure 2-3 (Keynani, 2011). Diode is reverse-biased. Input is disconnected from the output, no energy flows from input to output, output gets energy from capacitor, $V_{LON} = V_s$.

The inductor voltage

$$\begin{aligned} V_L &= V_s \\ &= L \frac{di_L}{dt} \Rightarrow \frac{di_L}{dt} = \frac{V_s}{L} \end{aligned} \quad (2.4)$$

Since the derivative of i_L is a +ve constant, therefore i_L must increase linearly;

$$\begin{aligned} \frac{di_L}{dt} &= \frac{\Delta i_L}{\Delta t} = \frac{\Delta i_L}{DT} = \frac{V_s}{L} \\ (\Delta i_L)_{closed} &= \left(\frac{V_s}{L} \right) \cdot DT \end{aligned} \quad (2.5)$$

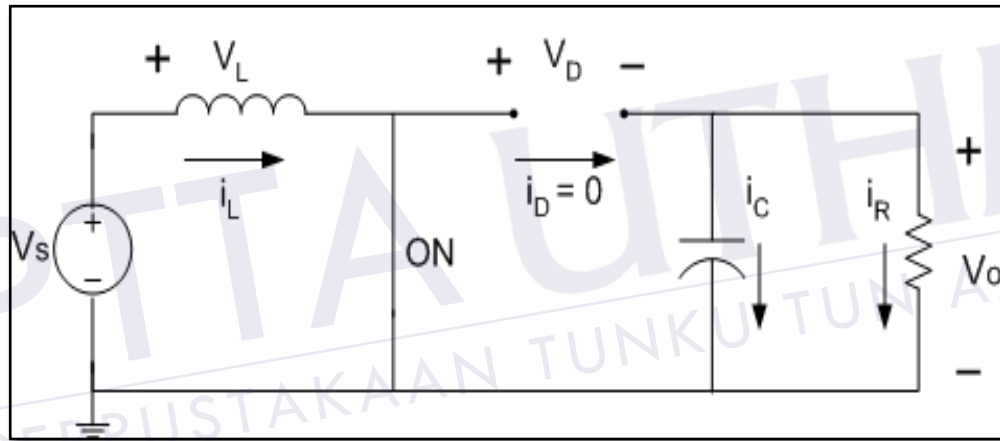


Figure 2- 3 The Equivalent Circuit of Boost Converter When the Switch S is closed

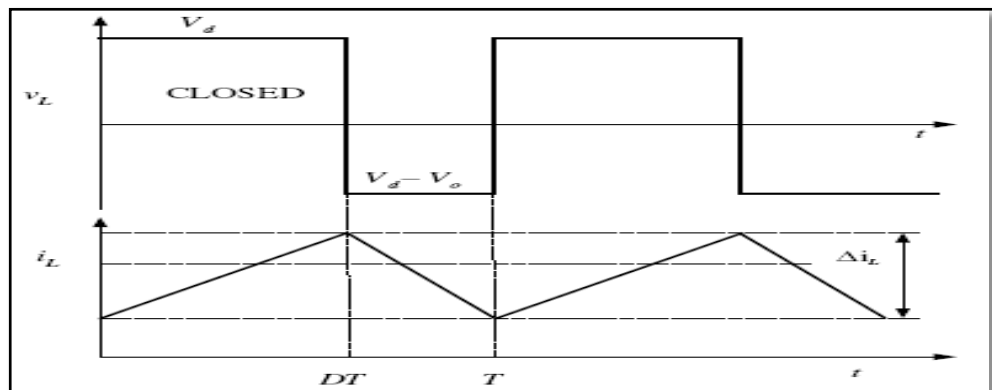


Figure 2- 4 Analysis for switch closed(on)

2.3.2 Analysis for switch open (off)

For the next cycle, the power switches S open. The condition is depicted in Figure 2-5. Because the inductor fully charged in the previous cycle, it will continue to force its current through the diode D to the output circuit and charge the capacitor.

Inductor is discharging, diode is forward-biased, and Input is connected to the output, energy flows from input to output while capacitor's energy is replenished. The output stage receives energy from the input as well as from the inductor, $V_{LOFF} = V_s - V_o$.

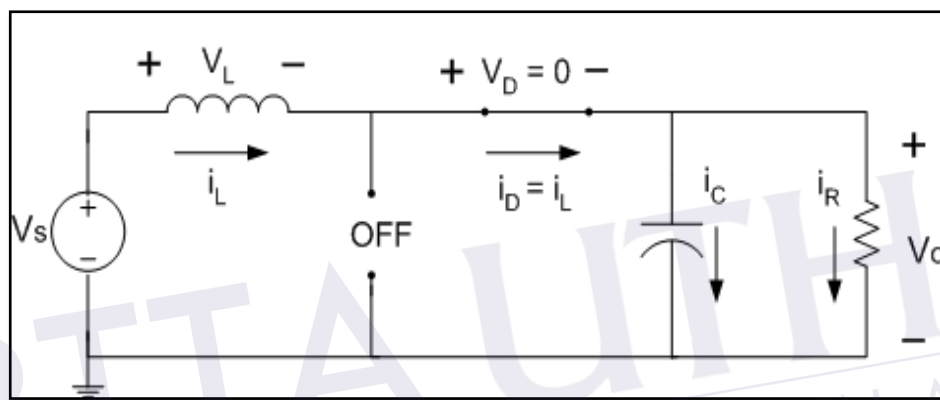


Figure 2-5 The Equivalent Circuit of Boost Converter When the Switch S Open

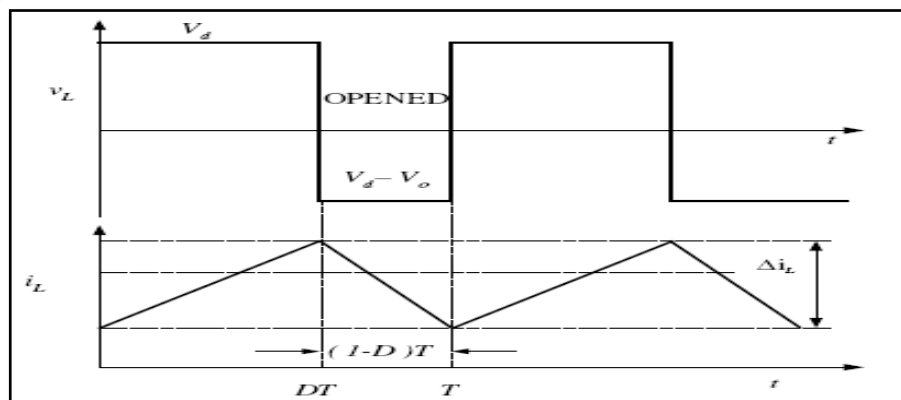


Figure 2-6 Analysis for switch opened (off)

The inductor voltage

$$\begin{aligned} V_L &= V_s - V_o \\ &= L \frac{di_L}{dt} \Rightarrow \frac{di_L}{dt} = \frac{V_s - V_o}{L} \end{aligned} \quad (2.6)$$

Since the derivative of i_L is a -ve constant, therefore i_L must decrease linearly.

$$\begin{aligned} \frac{di_L}{dt} &= \frac{\Delta i_L}{\Delta t} = \frac{\Delta i_L}{(1-D)T} = \frac{V_s - V_o}{L} \\ (\Delta i_L)_{opened} &= \left(\frac{V_s - V_o}{L} \right) \cdot (1-D)T \end{aligned} \quad (2.7)$$

Steady-state operation

$$\begin{aligned} (\Delta i_L)_{closed} + (\Delta i_L)_{opened} &= 0 \\ \left(\frac{V_s}{L} \right) \cdot DT + \left(\frac{V_s - V_o}{L} \right) \cdot (1-D)T &= 0 \\ \Rightarrow V_o &= \frac{V_s}{1-D} \end{aligned} \quad (2.8)$$

In steady state the average inductor voltage is zero over one switching period knownas **Volt Second Balance**,

$$\begin{aligned} V_{LON}t_{ON} + V_{LOFF}t_{OFF} &= 0 \\ V_s DT + (V_s - V_o)(1-D)T &= 0 \\ \boxed{V_o = \frac{1}{1-D} \cdot V_s} \end{aligned} \quad (2.9)$$

From the equation (2.9) average output voltage is higher than input voltage.

Inductor current:

Input power = Output power

$$I_L = \frac{V_s}{(1-D)^2 R} \quad (2.10)$$

Average inductor current

$$V_s I_s = \frac{V_o^2}{R}$$

$$V_s I_L = \frac{\left(\frac{V_s}{1-D}\right)^2}{R} = \frac{V_s^2}{(1-D)^2 R} \quad (2.11)$$

2.3.3 Boost Converter modes of operation

The DC-DC converters can have two distinct modes of operation: Continuous conduction mode (CCM) and discontinuous conduction mode (DCM). In practice, a converter may operate in both modes, which have significantly different characteristics. However, for this project only consider the DC-DC converters operated in CCM . CCM IS for efficient power conversion and Discontinuous Conduction Mode DCM for low power or stand-by operation (**B. M Hasaneen, December 2008**).

- Continuous Conduction Mode (CCM) when inductor current > 0
- Discontinuous Conduction Mode (DCM) when inductor current goes to 0 and stays at 0 for some time.

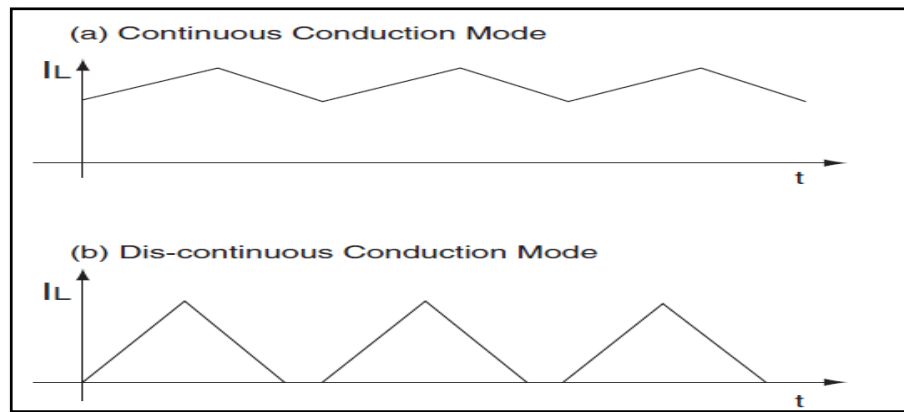


Figure 2-7 (a) CCM Mode (b) DCM Mode

2.4 PID Controller

Most of the control techniques for DC motor controller in industrial applications are embedded with the Proportional-Integral-Derivative (PID) controller. PID control is one of the oldest techniques. It uses one of its families of controllers including P, PD, PI and PID controllers. There are two reasons why nowadays it is still the majority and important in industrial applications. First, its popularity stems from the fact that the control engineer essentially only has to determine the best setting for proportional, integral and derivative control action needed to achieve a desired closed-loop performance that obtained from the well-known Ziegler-Nichols tuning procedure .

A proportional integral derivation controller (PID Controller) is a generic control loop feedback mechanism widely used in industrial control system. A PID is most commonly used feedback controller. Over 90% of the controllers in operation today are PID controllers (or at least some form of PID controller like a P or PI controller). This approach is often viewed as simple, reliable, and easy to understand.

Controllers respond to the error between a selected set point and the offset or error signal that is the difference between the measurement value and the set point. Optimum values can be computed based upon the natural frequency of a system. Too

much feedback (positive feedback cause stability problems) causes increasing oscillation.

With proportional (gain) only control the output increases or decreases to a new value that is proportional to the error. Higher gain makes the output change larger corresponding to the error. Integral can be added to the proportional action to ramp the output at a particular rate thus bring the error back toward zero. Derivative can be added as a momentary spike of corrective action that tails off. Derivative can be a bad thing with a noisy signal.

Typical steps for designing a PID controller are;

- i. Determine what characteristics of the system need to be improved.
- ii. Use K_P to decrease the rise time.
- iii. Use K_D to reduce the overshoot and settling time.
- iv. Use K_I to eliminate the steady-state error.

2.5 Fuzzy logic controller system

The concept of Fuzzy Logic (FL) was conceived by Lotfi Zadeh, a professor at the University of California at Berkley, and presented not as a control methodology, but as a way of processing data by allowing partial set membership rather than crisp set membership or non-membership. This approach to set theory was not applied to control systems until the 70's due to insufficient small-computer capability prior to that time. Professor Zadeh reasoned that people do not require precise, numerical information input, and yet they are capable of highly adaptive control. If feedback controllers could be programmed to accept noisy, imprecise input, they would be much more effective and perhaps easier to implement. Unfortunately, U.S. manufacturers have not been so quick to embrace this technology while the Europeans and Japanese have been aggressively building real products around it.

Fuzzy logic and fuzzy control theories added a new dimension to control systems engineering in the early 1970s. From its beginnings as mostly heuristic, somewhat ad-hoc, more recent and rigorous approaches to fuzzy control theory have helped make it integral part of modern control theory and produced many exciting results.

There are four important elements in the fuzzy logic controller system structure which are fuzzifier, rule base, inference engine and defuzzifier. Details of the fuzzy logic controller system structure can be seen in Figure 2.8 below. Firstly, a crisp set of input data are gathered and converted to a fuzzy set using fuzzy linguistic variables, fuzzy linguistic terms and membership functions. This step also known as fuzzification. Afterwards, an inference is made base on a set of rules. Lastly, the resulting fuzzy output is mapped to a crisp output using the membership functions, in the defuzzification step.

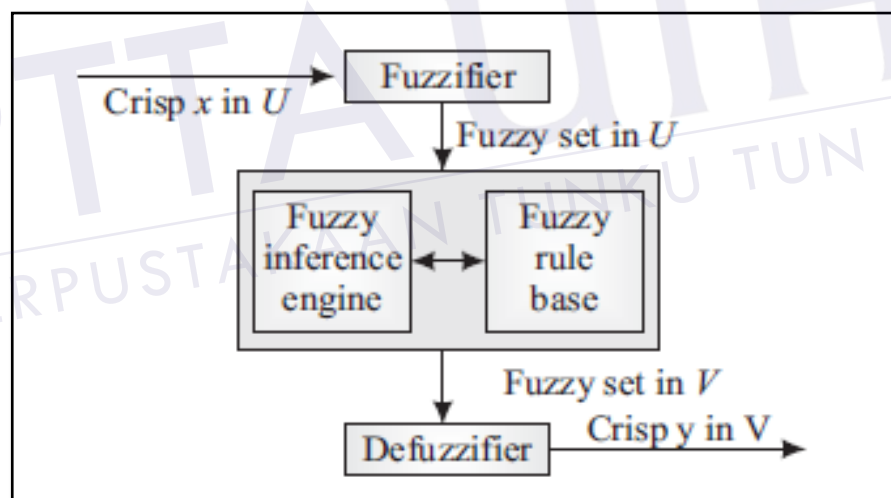


Figure 2.8: Structure of fuzzy logic controller system

2.5.1 Fuzzification

Fuzzification is a process of making a crisp quantity fuzzy. Before this process is taken in action, the definition of the linguistic variables and terms is needed.

Linguistic variables are the input or output variables of the system whose values are words or sentences from a natural language, instead of numerical values. A linguistic variable is generally decomposed into asset of linguistic terms.

Next, to map the non-fuzzy input or crisp input data to fuzzy linguistic terms, membership functions is used. In other words, a membership function as shown in figure 2.9 is used to quantify a linguistic term. Note that, an important characteristic of fuzzy logic is that a numerical value does not have to be fuzzified using only one membership function meaning, a value can belong to multiple sets at the same time. There are different forms or shapes of membership functions such as Triangular, Gaussian, Ttrapezoidal, Generalized Bell and Sigmoidal. Figure 2.10 (a-e) shows the different types of membership function shape.

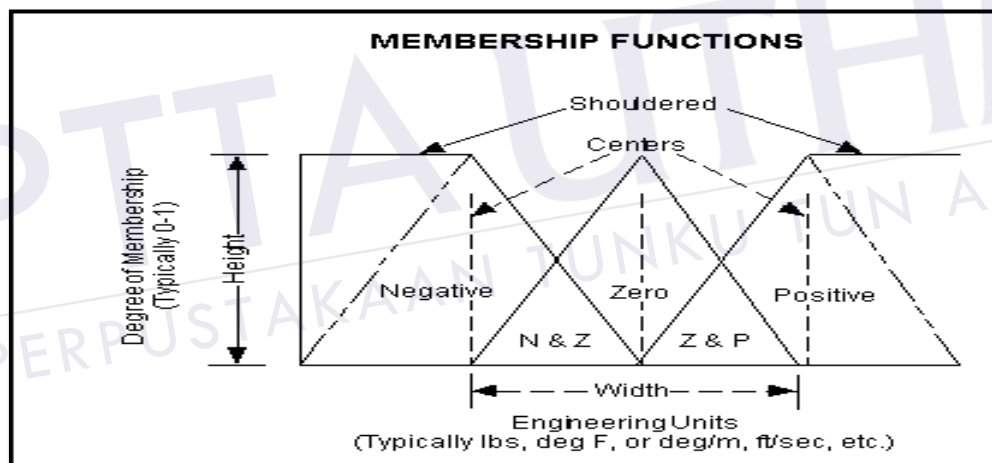


Figure 2.9: The features of a membership function (Kaehler, 1998)

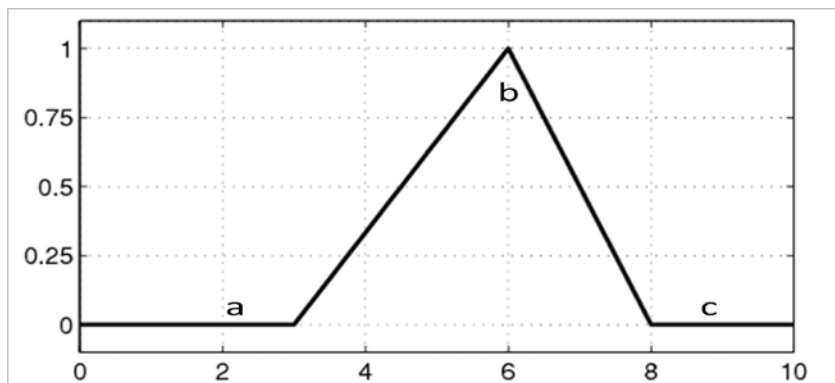


Figure 2.10(a): Triangular membership function shape

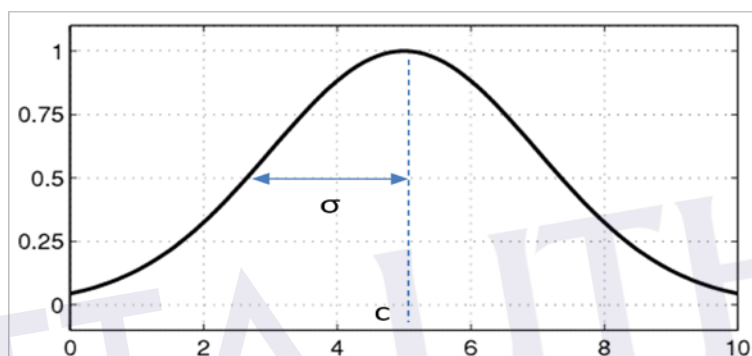


Figure 2.10 (b): Gaussian membership function shape

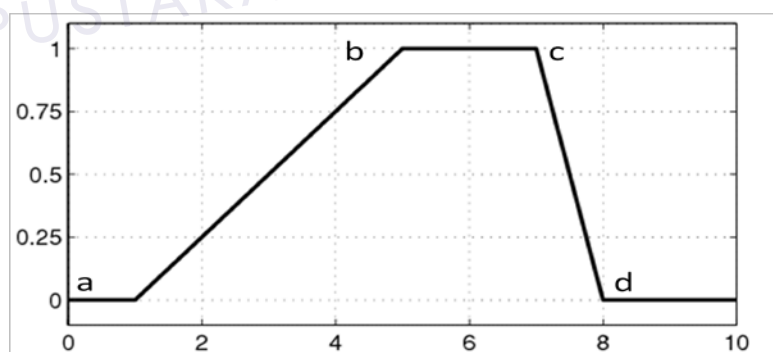


Figure 2.10 (c): Trapezoidal membership function shape

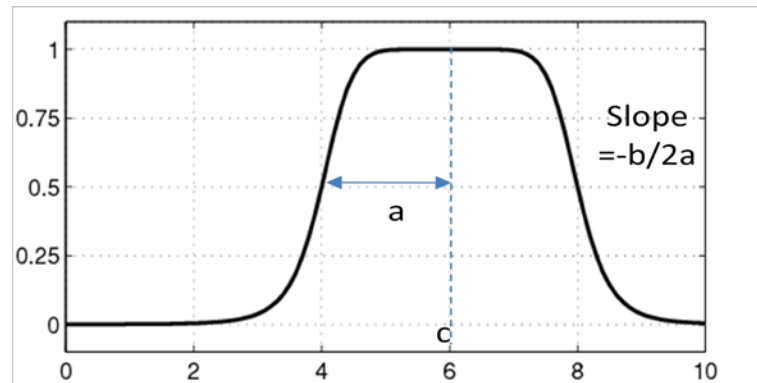


Figure 2.10(d): Generalized bell membership function shape

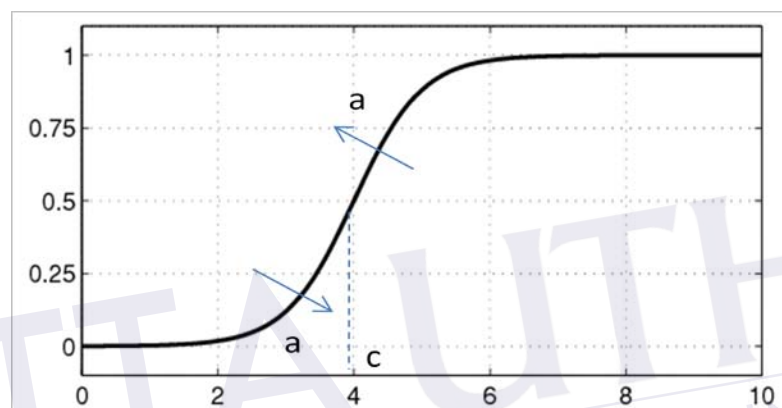


Figure 2.10(e): Sigmoidal membership function shape

2.5.2 Rule base

In a fuzzy logic control system, a rule base is constructed to control the output variable. A fuzzy rule is a simple IF-THEN rule with a condition and conclusion. It can be represented by the matrix table. The premise variables *error* and *change in error* are laid out along the axes, and the conclusions are inside the table. (Jantzen, 2007) . The most prominent connective is the ‘and’ connective, often implemented as multiplication instead of minimum. For examples ‘If *error* is Neg and *change in error* is Pos then *control* is Zero

Table 2.1: Example of rule base for air conditioner system

Control		Change in Error		
		NB	NM	Zero
Error	Neg	NB	NM	Zero
	Zero	NM	Zero	PM
	Pos	Zero	PM	PB

2.5.3 Rules of Inference

In general, inference is a process of obtaining new knowledge through existing knowledge. In the context of fuzzy logic control system, it can be defined as a process to obtain the final result of combination of the result of each rule in fuzzy value. There are many methods to perform fuzzy inference method and the most common two of them are Mamdani and Takagi-Sugeno-Kang method.

Mamdani method was proposed by Ebrahim Mamdani as an attempt to control a steam engine and boiler in 1975. It is based on Lofti Zadeh's 1973 paper on fuzzy algorithms for complex system and decision processes. This method uses the minimum operation R_c as a fuzzy implication and the max-min operator for the composition. Suppose a rule base is given in the following form;

IF input $x = A$ AND input $y = B$
THEN output $z = C$

After the aggregation process, there is a fuzzy set for each output variable that needs defuzzification. It is possible and in many cases much more efficient, to use a single spike as the output membership functions rather than a distributed fuzzy set. This is sometimes known as a singleton output membership function. It enhances the efficiency of defuzzification process because it greatly simplifies the computation required by the more general Mamdani method, which finds the centroid of two dimensional function.

Meanwhile, Takagi-Sugeno-Kang method was introduced in 1985 and it is similar to the Mamdani method in many aspects. The first two parts of fuzzy inference processes which are fuzzifying the inputs and applying the fuzzy operator are exactly the same. But, the main difference is that the Takagi-Sugeno-Kang output membership function is either linear or constant. A typical rule in Takagi-Sugeno-Kang fuzzy model has the form as follows;

IF input 1 = x AND input 2 = y
THEN output z = ax + by + c

2.5.4 Defuzzification

After the inference step, the overall result is a fuzzy value. This result should be defuzzified to obtain a final crisp output. This is the purpose of the defuzzification component of a fuzzy logic controller system. Defuzzification is performed according to the membership function of the output variable. There are many different methods for defuzzification such as Centroid of Gravity (COG), Mean of Maximum (MOM), Weighted Average, Bisector of Area (BOA), First of Maxima and Last of Maxima. There is no systematic procedure for choosing a good defuzzification strategy, but the selection of defuzzification procedure is depends on the properties of the application.

Centroid of Gravity (COG) is the most frequent used and the most prevalent and physically appealing of all defuzzification methods. The basic equation of Centroid of Gravity (COG) as below;

$$u_o = \frac{\int_u \mu_u(u)udu}{\int_u \mu_u(u)du} \quad (2.12)$$

where u_o is control output obtained by using Centroid of Gravity (COG) defuzzification method.

2.5.5 Advantages of Fuzzy Logic Controller

There are the advantages if using fuzzy logic controller:-

- i. Fuzzy logic is suited to low-cost implementations based on cheap sensors, low-resolution analog-to-digital converter
- ii. Systems can be easily upgraded by adding new rules to improve performance or add new features.
- iii. Fuzzy control can be used to improve existing traditional controller systems by adding an extra layer of intelligence to the current control method.



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CHAPTER 3

METHODOLOGY

3.1 Project Design

The proposed general block diagram for this project is shown in figure 3-1 and Figure 3.2 shows the overview of the methodology flow chart of this project.

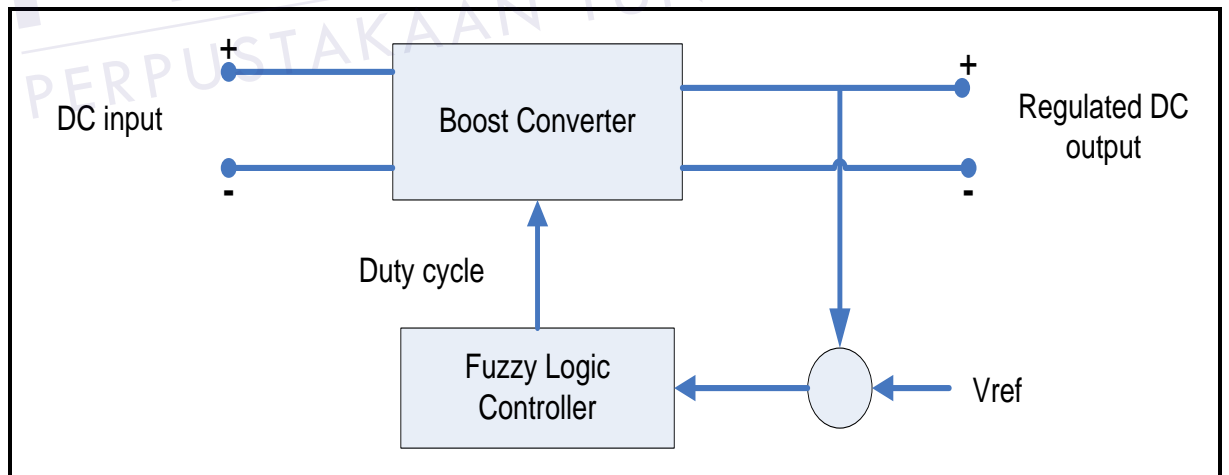


Figure 3 - 1: Block Diagram For Propose DC-DC Boost Converter Using Fuzzy Logic Controller

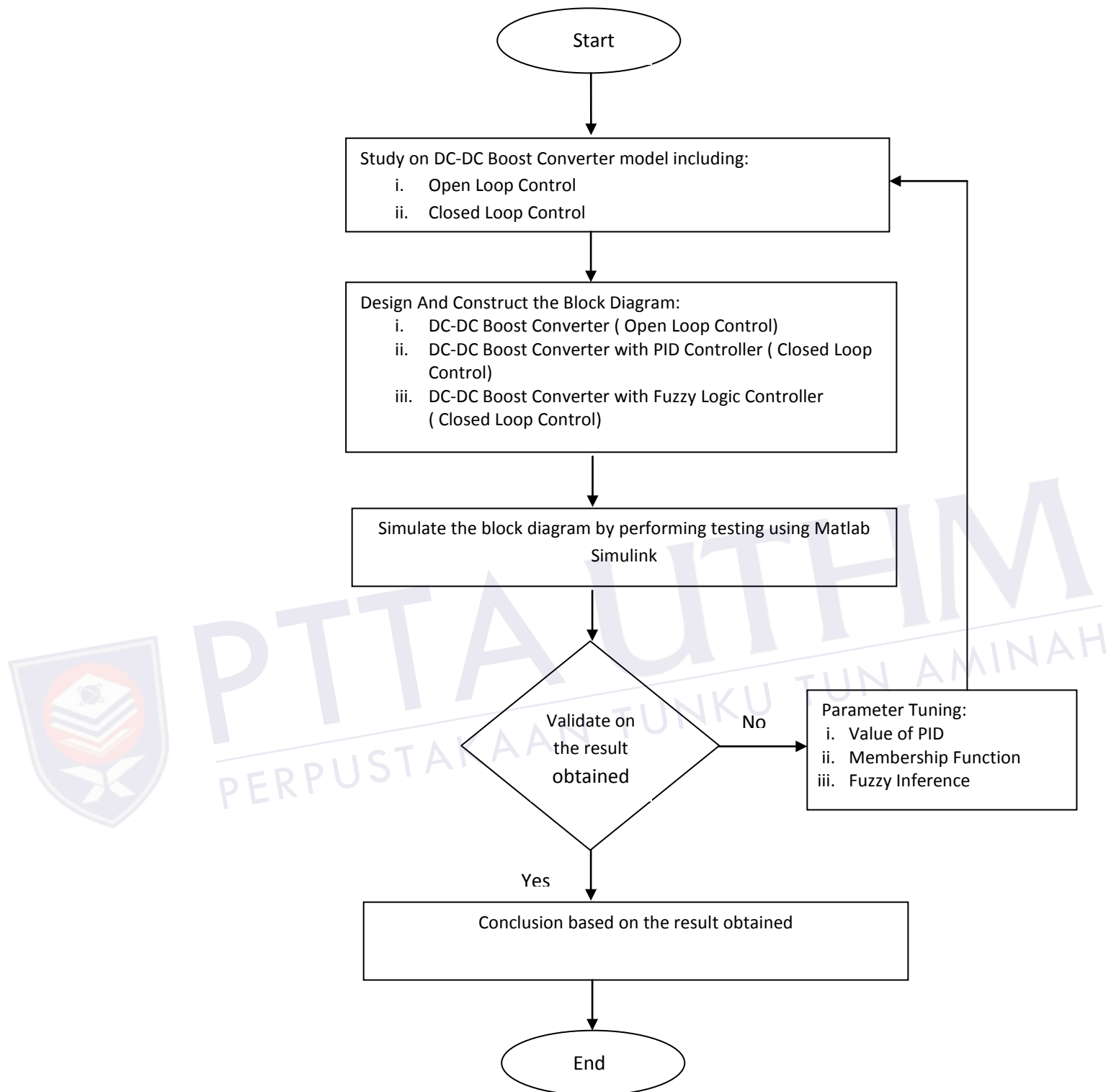


Figure 3 - 2: The Methodology Flow Chart

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